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Attorney Docket No. 040894-7026

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
Takuto YOSHIDA, et al.	Confirmation No.: 9332
Application No.: 10/830,220	Group Art Unit: 2829
Filed: April 23, 2004	Examiner: Roberto Valez
For: INSPECTION COAXIAL PROBE AND INSPECTION UNIT INCORPORATING THE SAME	

Commissioner for Patents
U.S. Patent and Trademark Office
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Alexandria, VA 22314

Sir:

SUBMISSION OF VERIFIED TRANSLATION

Applicants submit herewith a Verified Translation of Japanese Patent Application No. P2003-121574, filed in Japan on April 25, 2003. A certified copy of the priority document was filed in the above-identified application on April 23, 2004.

Applicants do not believe that any fees are required with this submission and respectfully request that this Translation be made of record in this application.

EXCEPT for issue fees payable under 37 C.F.R. § 1.18, the Commissioner is hereby authorized by this paper to charge any additional fees during the entire pendency of this application including fees due under 37 C.F.R. §§ 1.16 and 1.17 which may be required,

including any required extension of time fees, or credit any overpayment to Deposit Account 50-0310.

Respectfully Submitted,

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Sir:

VERIFICATION OF A TRANSLATION FOR JP APPLICATION P2003-121574

I, the below named translator, hereby declare that:

My name and post office address are as stated below;

That I am knowledgeable in the English language and in the Japanese language and believe the attached English translation to be a true and complete translation of the below identified document; and

The document for which the attached English translation is being submitted is Japanese Patent Application No. P2003-121574 filed in Japan on April 25, 2003. The Japanese language document was submitted to the U.S. Patent and Trademark Office on April 23, 2004 as the certified copy of the foreign priority application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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JAPAN PATENT OFFICE

This is to certify that the annexed is a true copy of the following application as filed with this office.

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Applicant (s) : YOKOWO CO., LTD.

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[Designation of Document] SPECIFICATION

[Title of the Invention] INSPECTION COAXIAL PROBE, AND INSPECTION UNIT USING THE SAME

[Claims]

[Claim 1] An inspection coaxial probe comprising:

contact probes, each being able to adjust the length to which a plunger projects from at least one end section of a metal pipe;

a metal block having insertion holes formed therein, each hole enable to insert the respective contact probe from at least one end; and

fixing means which fixes only end sections of said metal pipes on said metal block by way of an insulator while retaining said contact probes substantially concentrically with said insertion holes, wherein

an outer diameter of each of said metal pipes and an inner diameter of each of said insertion holes are set so as to form a coaxial structure of predetermined impedance while each of said contact probes is taken as a center conductor and said metal block is taken as an outer conductor.

[Claim 2] The inspection coaxial probe according to claim 1, wherein said fixing means is constituted such that insulating substrates which have respective recessed sections, each being made in conformance with said outer diameter of an extremity of said metal pipe, and respective through holes, said hole

being formed in said insulating substrate substantially concentric with said corresponding recessed sections and permitting penetration of said respective plungers, are fixed on respective surfaces of said metal block so that said recessed sections of said insulating substrates are made substantially concentric with said corresponding insertion holes of said metal block.

[Claim 3] The inspection coaxial probe according to claim 1, wherein said fixing means is formed such that a constriction section is formed at said metal block, in which one end of said insertion hole are formed, and said constriction section closes said insertion hole except for a through hole used for penetration of said plunger, and an insulating spacer which has a recessed section conforming in size to said outer diameter of an extremity of said metal pipe and a through hole, said hole being substantially concentric with said recessed section and permitting penetration of said plunger, is interposed between said constriction section and one end section of said contact probe.

[Claim 4] The inspection coaxial probe according to claim 1, wherein said fixing means is formed such that an insulating spacer having a recessed section conforming in size to an outer diameter of an extremity of said metal pipe and a through hole, which is substantially concentric with said recessed section and permits penetration of said plunger, is fitted around one

end section of said contact probe; and such that a metal cover provided with a recessed section conforming in size to an outer diameter of said insulating spacer and a through hole, which is substantially concentric with said recessed section and permits penetration of said plunger, is covered on said spacer and fixed on said surface of said metal block so that said recessed section of said metal cover is substantially concentric with said insertion hole.

[Claim 5] The inspection coaxial probe according to claim 1, wherein said fixing means is formed such that spacer fitting recesses, each recess having an inner diameter larger than that of said insertion hole, are formed in a surface of said metal block, in which one end of said insertion holes is formed; such that dielectric spacers, each spacer having a recessed section conforming in size to an outer diameter of an extremity of said metal pipe and a through hole, which is substantially concentric with said recessed section and permits penetration of said plunger, are inserted into said spacer fitting recesses of said metal block as well as into one end of said contact probe; and such that said insulating spacer is fixed by a wiring board secured on said surface of said metal block.

[Claim 6] The inspection coaxial probe according to any one of claims 1 through 5, wherein a hollow space is defined between said contact probe and said insertion hole of said metal block except for an area which is fixed by said fixing means.

[Claim 7] A inspecting unit for a high-frequency/high-speed device which performs electrical tests on a device to be inspected by an inspection circuit, wherein said inspection circuit comprises a metal block; RF signal contact probes which are provided on said metal block such that extremities of said plungers which are movable toward one surface of said metal block project; said device to be inspected is pressed against said one surface of said metal block, and RF signal electrode terminals of said device are brought into contact with said RF signal contact probes, so that said inspection circuit is connected to the other end sections of said RF contact probes, wherein at least a portion of said RF contact probes corresponds to inspection said coaxial probe defined in any one of claims 1 through 6.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to an inspection coaxial probe which establishes reliable connection between a device to be inspected and inspection equipment for inspecting an electrical characteristic of a module of high-frequency/high-speed circuitry (an analog high frequency is called a high frequency; a digital frequency having a very short pulse width and a very short pulse interval is called high speed; and both frequencies are hereinafter collectively

referred to as "RF"); for instance, an amplification circuit or a mixer circuit, which are to be incorporated into, e.g., a portable cellular phone, or a filter circuit, or an IC before the module or IC is incorporated into a circuit board, as well as to an inspection unit using the coaxial probe. More specifically, the present invention relates to a coaxial probe for use in inspecting an RF device which eliminates a necessity for soldering a device to be inspected; which can effect full electrical contact even at an RF range; and which can also establish connection with the device to be inspected through use of a coaxial structure—which is free from the influence of noise—even when electrode terminals of the device are arranged at a very narrow pitch of 0.4 mm or thereabouts, as well as to an inspection unit using the coaxial probe.

[0002]

[Related Art]

When an electrical characteristic of an RF device, such as a semiconductor wafer, an IC, or a module, is inspected, if, particularly, a contact status of a terminal section is incomplete, impedance will vary and a measured value will fluctuate. For this reason, inspection is performed through use of a jig such as that shown in Fig. 8. Specifically, in order to prevent interference with the surrounding, an RF circuit, which is a device to be inspected, is assembled into a module 50 by incorporating an amplification circuit and a mixer circuit

into a metal housing. RF signal input and output terminals 51, 54, a power electrode terminal 52, and a ground (earth) electrode terminal 53 are provided on the back of the housing. The RF circuit is inspected by electrically connecting the RF circuit to respective terminals of a wiring board 66 on which wiring for inspection is laid.

[0003]

An example shown in Fig. 8 adopts a following configuration. Specifically, the configuration uses contact probes, wherein each contact probe is constituted by inserting a spring and one end of a plunger in a metal pipe such that the plunger is projected outwardly by the spring and such that the plunger is withdrawn when depressed. Electrode terminals are connected together by placing Rf signal contact probes 63, power contact probes 64, and earth contact probes 65 within a metal block 61 for preventing influence of noise. In order to diminish an inductance component, the RF signal contact probe 63 is formed into a short probe having a length of, e.g., 2 mm or thereabouts. Even in the case of such a short probe, difficulty is encountered in diminishing a reactance component of the probe to 1 nH or less at an RF range. For instance, the probe of 1 nH yields impedance of 63 Ω at 10 GHz.

[0004]

Therefore, there is employed a coaxial line having a structure such that a dielectric tube is interposed between

the RF signal contact probe 63 and the metal block 61 and the contact probe 63 is taken as a center conductor and the metal block 61 is taken as an outer conductor, to thus prevent an increase in impedance or intrusion of noise (see, e.g., Patent Document 1). In Fig. 8, reference numeral 67 designates a coaxial cable; and 68 designates a presser plate for pressing the metal pipe provided around an outer periphery of the contact probe.

[0005]

Even when an IC is inspected, lead terminals of an IC and a wiring board are connected together by way of an IC socket formed from a leaf spring. For instance, as can be seen from an exploded descriptive view and a descriptive plan view of an IC socket in Fig. 9, an IC socket 70 is formed of a block 71 made of plastic or ceramic, and contact probes 72 are analogous to those mentioned previously and arranged in a matrix pattern in agreement with electrode terminals 73a of an IC 73. The IC is connected to the wiring laid on a multilayer wiring board 75 by way of the IC socket 70.

[0006]

[Patent Document 1]

JP-A-2001-99889

[0007]

[Problems that the Invention is to Solve]

As mentioned previously, probes to be connected with

respective electrode terminals are coated with a metal block. Further, RF signal contact probes are constituted in the form of a coaxial line, thereby preventing occurrence of reflection or attenuation of an RF signal, and thereby preventing intrusion of external noise or delivery of noise to other electrode terminals. Herewith, a jig for inspecting an RF device is constituted. However, Fig. 8 shows two RF signal contact probes 53 (for input and output), one power contact probe, and one earth contact probe. In reality, plurality of the probes is formed. Further, in association with a recent increase in the degree of integration of an IC, there may arise a case where electrode terminals having an area of about $600/cm^2$ are provided in a matrix pattern. An IC having electrode terminals arranged at a narrow pitch of 0.4 mm or thereabouts has come into existence.

[0008]

In order to achieve predetermined impedance by the coaxial structure such as that mentioned previously, an outer diameter "d" of the contact probe serving as a center conductor and an inner diameter "D" of a hole of the metal block serving as an outer conductor must satisfy the relationship expressed by Equation (1) provided below while a relative dielectric constant of a dielectric substance interposed between the center conductor and the outer conductor is taken as ε_r. Therefore, even when an attempt is made to realize a coaxial structure having an impedance of 50 Ω through use of a tube formed from

polytetrafluoroethylene, which is known as a dielectric having a small relative dielectric constant on the order of 2.1, the inner diameter of the hole formed in the metal block must be about 3.3 times as large as the outer diameter of the contact probe. Thus, the contact probes may fail to be compatible with a device to be inspected which has a narrow pitch of about 0.4 mm or less, unless the outer diameter of the contact probe is reduced to 0.1 mm or less.

[0009]

[Mathematical Equation 1]

$$Zo = \frac{60}{\sqrt{\varepsilon_r}} \log_e \frac{D}{d} \quad \ldots \quad (1)$$

[0010]

However, the contact probe has a structure in which a spring and a plunger are inserted into a metal pipe. If the outer diameter of the contact probe is reduced excessively, the contact probe becomes very costly. Further, there is raised a problem of a drop in durability and reliability of the contact probe.

[0011]

The present invention has been conceived to solve such a problem. An object of the present invention is to provide a coaxial probe for inspecting an RF device which can perform highly reliably inspection without being affected by noise, through use of inexpensive contact probes of coaxial structures

even when a recent RF device having electrode terminals arranged at a very small pitch is inspected.

[0012]

Another object of the present invention is to provide specific fixing means which can tightly retain contact probes in the centers of respective insertion holes, by adopting a coaxial structure capable of defining a hollow section between the outer diameter of the contact probe and the insertion hole of the metal block, thereby reducing a ratio of the inner diameter to the outer diameter of the coaxial structure and making an attempt to render the coaxial structure compact.

[0013]

Still another object of the present invention is to provide an inspection unit using such coaxial probes.

[0014]

[Means for Solving the Problem]

As mentioned previously, in order to perform inspection without causing attenuation of an RF signal, even when an IC or module having a small pitch between electrode terminals is inspected, the present inventors have conducted considerable study and attempted to define a hollow space between a contact probe and an inner wall of a through hole formed in a metal block. Specifically, as a result of a hollow space having been defined between the contact probe and the inner wall of the through hole of the metal block, a relative dielectric constant

of a dielectric substance interposed between a center conductor and an outer conductor assumes a value of one, and hence an inner diameter D of the outer conductor can be set to about 2.3 times as large as an outer diameter d of the center conductor.

[0015]

However, when an attempt is made to define a hollow space between the center conductor and the outer conductor within a coaxial structure, the contact probe cannot be retained at the center of the through hole by the conventional structure in which the contact probe is inserted into the through hole of the metal block and the thus-inserted contact probe is pressed by a presser plate. Moreover, when the number of probes has increased from tens to hundreds, the force originating from the entirety of the contact probes becomes large and unbearable for the presser plate, thereby inducing warpage in the presser plate. Thereby, the presser plate comes into contact with the electrode terminals of the device before the contact probes come into contact with the same. As a result, the device or the electrode terminals of the device are susceptible to fracture, or the presser plate becomes liable to fracture due to abrasion. If warpage has become excessively large, the center of the device exceeds the height of an edge of a plunger, which in turn raises a fatal problem of a failure to support the contact probe as the coaxial structure. There may also arise a problem of the contact probe becoming decentered and unusable as the coaxial

structure or inducing a short circuit. For these reasons, the present inventors have contrived a special fixing structure of a contact probe, thereby enabling formation of a hollow space. Thus, a coaxial probe compatible with a structure involving a narrow pitch has been invented.

[0016]

An inspection coaxial probe according to the invention comprises contact probes, each being able to adjust the length to which the plunger projects from at least one end section of a metal pipe; the metal block having insertion holes formed therein, each hole enable to insert the respective contact probe from at least one end; and fixing means which fixes only end sections of the metal pipes on the metal block by way of an insulator while retaining the contact probes substantially concentrically with the insertion holes, wherein an outer diameter of each of the metal pipes and an inner diameter of each of the insertion holes are set so as to form a coaxial structure of predetermined impedance while taking each of the contact probes as the center conductor and the metal block as the outer conductor.

[0017]

Here, the contact probe means a probe having the following structure. Specifically, lead wires (plungers) are provided in, e.g., the metal pipe, by way of a spring, such that one end section of each of the plungers projects from the metal

pipe and the other end of each of the plungers is not dislodged from the metal pipe. When one end of the plunger is depressed, the one end section is withdrawn to the end section of the metal pipe, and, when external force is relieved, the plunger projects outward from the metal pipe under the force of the spring. Thus, the extremities of the lead wires (plungers) can move.

[0018]

By such a structure, the end section of the contact probe is firmly retained substantially concentrically in the insertion hole formed in the metal block, by the fixing means. Accordingly, an air layer can be defined between the contact probe and the metal block over the majority of the length of the contact probe. Consequently, the relative dielectric constant ε_r of the dielectric substance in Equation (1) can be deemed to be substantially one. Even when the coaxial structure is imparted with an impedance of 50 Ω, the only requirement is to render the inner diameter of the insertion hole 2.3 times as large as the outer diameter of the center conductor. Even in the case of a device to be inspected having a pitch of 0.4 mm between electrode terminals, a coaxial structure of 50 Ω can be constituted of a contact probe having an outer diameter of 0.15 mm and an insertion hole having an inner diameter of 0.35 mm.

[0019]

The fixing means can be constituted such that insulating

substrates which have respective recessed sections, each being made in conformance with the outer diameter of an extremity of the metal pipe, and respective through holes, the hole being formed in the insulating substrate substantially concentric with the corresponding recessed sections and permitting penetration of the respective plungers, are fixed on respective surfaces of the metal block so that the recessed sections of the insulating substrates are made substantially concentric with the corresponding insertion holes of the metal block. If this structure is adopted, the contact probes can be retained while the extremities of the metal pipes are retained firmly through use of the insulating substrates possessing mechanical strength; e.g., polyetherimide (PEI) having a thickness of about 1 mm. As a result, movement of the contact probes or occurrence of warpage in the insulating substrates can be prevented. Further, even when the hollow space is defined between the contact probes and the inner walls of the insertion holes, an accurate coaxial characteristic can be maintained. In this case, no coaxial structure is formed within the thickness portions of the dielectric substrates. However, as will be described later, absence of a coaxial structure poses little influence at a frequency of 10 GHz or less. Return loss assumes a value of -20 dB or less at a frequency of about 10 GHz or less. Hence, no practical problem arises at actual use.

[0020]

Further, the fixing means may be formed such that a constriction section is formed at the metal block, in which one end of the insertion hole are formed, and the constriction section closes the insertion hole except for a through hole used for penetration of the plunger, and an insulating spacer which has a recessed section conforming in size to the outer diameter of an extremity of the metal pipe and a through hole, the hole being substantially concentric with the recessed section and permitting penetration of the plunger, is interposed between the constriction section and one end section of the contact probe. By this structure, the contact probe is fixed by the metal block by way of the insulating spacers, and hence high mechanical strength can be achieved. Further, even when the number of coaxial probes is extremely large, the probes can be fixed without involvement of warpage. Here, when both ends of each of the contact probes are fixed, another fixing means is used for fixing the other end of the contact probe.

[0021]

The fixing means may be formed such that an insulating spacer having a recessed section conforming in size to an outer diameter of an extremity of the metal pipe and a through hole, which is substantially concentric with the recessed section and permits penetration of the plunger, is fitted around one end section of the contact probe; and such that a metal cover provided with a recessed section conforming in size to an outer

diameter of the insulating spacer and a through hole, which is substantially concentric with the recessed section and permits penetration of the plunger, is covered on the spacer and fixed on the surface of the metal block so that the recessed section of the metal cover is substantially concentric with the insertion hole. By this structure, the contact probes can be fixed by attaching only the metal cover on the surface of the metal block by way of the insulating spacer. There is no necessity for inserting the contact probes into the constriction sections formed in the metal block by way of the insulating spacers. Hence, the coaxial probe can be assembled very easily but can attain the same mechanical strength as that achieved when the contact probes are inserted into the constriction sections. Further, even when there is a necessity for fixing both ends of each of the contact probes, both end sections can be fixed by this structure.

[0022]

The fixing means can also be formed in a structure such that spacer fitting recesses, each recess having an inner diameter larger than that of the insertion hole, are formed in a surface of the metal block, in which one end of the insertion holes is formed; such that dielectric spacers, each spacer having a recessed section conforming in size to an outer diameter of an extremity of the metal pipe and a through hole, which is substantially concentric with the recessed section and permits

penetration of the plunger, are inserted into the spacer fitting recesses of the metal block as well as into one end of the contact probe; and such that the insulating spacer is fixed by a wiring board secured on the surface of the metal block. By this structure, the contact probes cannot be fixed by a single coaxial probe structure (i.e., a combination of a metal block and contact probes). However, an inspection unit is usually provided with a wiring board and hence can be readily secured by utilization of the wiring board.

[0023]

If the hollow space is defined between the contact probe and the insertion hole of the metal block except for an area which is fixed by the fixing means, the diameter of the insertion hole can be reduced even when a given characteristic impedance is to be attained. Thus, the contact probes can preferably cope with a reduction in the pitch between the electrode terminals.

[0024]

A inspecting unit for a high-frequency/high-speed device according to the present invention performs electrical tests on a device to be inspected by an inspection circuit, wherein the inspection circuit comprises a metal block; RF signal contact probes which are provided on the metal block such that extremities of the plungers which are movable toward one surface of the metal block project; the device to be inspected is pressed

against the one surface of the metal block, and RF signal electrode terminals of the device are brought into contact with the RF signal contact probes, so that the inspection circuit is connected to the other end sections of the RF contact probes, wherein at least a portion of the RF contact probes corresponds to inspection the coaxial probe defined in any one of claims 1 through 6.

[0025]

Here, an RF encompasses an analog high frequency and a high-speed digital short pulse having a short pulse interval, wherein an iteration rate of a sinusoidal wave or pulses is 1 GHz or more.

[0026]

[Modes for Implementing the Invention]

An inspection coaxial probe and a unit for inspecting an RF device using the coaxial probe, both according to the present invention, will be described by reference to the drawings.

[0027]

As can be seen from a cross-sectional descriptive view of an embodiment of the inspection coaxial probe of the invention shown in Fig. 1, the inspection coaxial probe comprises contact probes 1 inserted in respective insertion holes 21 of a metal block 2, wherein the contact probe 1 is provided with a spring 14 and plungers 11, 12, all being inserted in a metal pipe 13,

and wherein the length to which the plunger 11 or 12 projects from at least one end of the metal pipe 13 can be adjusted. The inspection coaxial probe is provided with fixing means 3 for fixing each of the contact probes 1 in the metal block 2 by way of an insulator (an insulating substrate 31 in the embodiment shown in Fig. 1) which retains an end section of the metal pipe 13 substantially concentric with the respective insertion hole 21. An outer diameter of the metal pipe 13 and an inner diameter of the insertion hole 21 are set such that there is formed a coaxial structure of predetermined impedance while each of the contact probes 1 is taken as a center conductor and the metal block 2 is taken as an outer conductor. Although the drawing is illustrated as if a large gap is present between the insulating substrate 31 and the end section of the metal pipe, the insulating substrate 31 and the metal pipe are actually almost fitted together.

[0028]

For instance, as can be seen from the cross-sectional descriptive view shown in Fig. 1(b), the contact probe 1 has a structure in which the spring 14 and one end of each of the plungers (movable pins) 11, 12 are housed within the metal pipe 13; in which recessed sections 13a formed in the metal pipe 13 prevent the plungers 11, 12 from being dislodged from the metal pipe 13, and the plungers 11, 12 are forced outwardly by the spring 14; and in which the spring 14 contracts and is

compressed into the metal pipe 13 when the extremities of the plungers 11, 12 are pressed, and the extremity of the plunger 11 projects to, e.g., 1 mm or thereabouts, when no force is exerted on the contact probe 1. The embodiment shown in Fig. 1 shows a structure in which the plungers 11, 12 are provided at respective ends of the metal pipe 13. However, any structure is allowable, so long as at least one side of the contact probe 1 which is to contact a device to be inspected is provided with the plunger 11. The metal pipe 13 assumes a length of about several millimeters and is formed from, e.g., white metal (e.g., an alloy consisting of copper, nickel, and zinc). A wire having a diameter of about 0.1 mm formed from, e.g., an SK material or a beryllium copper alloy is used for the plungers 11, 12, and the spring 14 is formed from piano wire.

[0029]

The metal block 2 is for retaining the contact probes 1, such as contact probes for an RF signal or contact probes for use with power electrode terminals, which are to be brought into contact with the electrode terminals of an IC or module which is a device to be inspected. For instance, the contact probe 1 can be constituted in a coaxial structure through use of a metal body, such as aluminum, wherein an inner wall of the insertion hole 21 into which the contact probe 1 is inserted is taken as an outer conductor and the contact probe 1 is taken as a center conductor. The inner diameter of the insertion

hole 21 is determined so as to yield predetermined impedance on the basis of Equation (1) in consideration of the relation between the outer diameter of the contact probe 1 and a dielectric constant of a dielectric substance interposed between the insertion hole 21 and the contact probe 1. When the probe is used as a signal probe for use with a d.c. or low-frequency signal or the probe is used as a power probe, the coaxial structure does not need to be adjusted to specific impedance, such as 50 Ω. The drawing shows that the metal block 2 is provided with only one contact probe 1. However, in an actual inspection unit, the metal block 2 is provided with a plurality of contact probes as shown in Fig. 6, which will be described later.

[0030]

The thickness and size of the metal block 2 varies according to an application; for example, an IC socket used for merely coupling an IC to an inspection board having wiring laid thereon or an inspection jig to be connected to a board connected to a coaxial cable or the like. However, the metal block 2 is usually formed assumes a thickness of 3 to 8 mm or thereabouts and a size of 30 to 50 mm or thereabouts per side.

[0031]

Fixing means 3 (31, 33, 34, 36, 38, and 39) is for fixing the contact probe 1 while retaining the same substantially concentrically with the insertion hole 21 of the metal block 2. In the embodiment shown in Fig. 1, the fixing means 3 is

formed from insulating substrates 31 provided on both surfaces of the metal block 2. Specifically, the insulating substrates 31 have respective recessed sections 31a conforming in shape to the end section of the metal pipe 13, and respective through holes 31b for permitting penetration of the plungers 11 substantially concentrically with the recessed sections 31a. Each of the insulating substrates 31 has a structure in which the insulating substrate 31 is fixed to the metal block 2 by unillustrated screws such that the recessed section 31a becomes concentric with the insertion hole 21 of the metal block 2. The embodiment shown in Fig. 1 adopts a structure in which both end sections of the contact probe 1 are fixed by the insulating substrates 31, and the insulating substrates 31 are provided on both sides of the metal block 2.

[0032]

Consequently, both end sections of the metal pipe 13 are fitted into the recessed sections 31a of the insulating substrates 31. Further, the recessed sections 31a are fixed in the metal block 2 so as to become concentric with the insertion hole 21 of the metal block 2. Therefore, the contact probe 1 is fixed in line with the center axis of the insertion hole 21. Moreover, the through holes 31b through which the plungers 11, 12 penetrate are formed in the respective insulating substrates 31. Therefore, the plungers 11, 12 project from the surfaces of the insulating substrates 31. When being

pressed by the device to be inspected, the plungers 11, 12 are depressed to the surfaces of the insulating substrates 31, whereupon reliable contact can be established between electrode terminals of the device to be inspected and wiring patterns of a wiring board.

[0033]

If an insulating substrate formed from resin; e.g., polyetherimide (PEI), is used as the insulating substrate 31, the recessed sections 31a and the through holes 31b can be more readily formed through resin molding and in accurate dimensions even when the plurality of contact probes 1 are arranged at narrow pitches. For this reason, the insulating substrate formed from resin is preferable as material of the insulating substrate 31. Further, if the insulating substrates 31 are formed from the foregoing resin, the substrates possess high mechanical strength. If the insulating substrates 31 are each formed to a thickness of about 1 mm, no warpage will arise and contact probes can be fixed very stably even when hundreds of contact probes or more are provided in the insulating substrates 31. However, another material may also be employed, so long as the material is thin and exhibits an electrical insulating characteristic and sufficient mechanical strength.

[0034]

The insulating substrates 31 serving as the fixing means 3 are constituted in the manner mentioned previously. Therefore,

so long as the outer diameter of each of the metal pipes 13 and the inner diameter of each of the insertion holes 21 have been set beforehand in accordance with Equation (1), the inspection coaxial probes can be readily formed, by fitting the extremities of the metal pipes 13 into the recessed sections 31a of the insulating substrates 31 and fixing the insulating substrates 31 on the metal block 2 through use of screws, even when a plurality of contact probes 1 is arranged in the form of an array. In the embodiment shown in Fig. 1(a), the insulating substrates 31 are formed to a thickness of about 1 mm. Since the portions of the contact probes 1 corresponding to the insulating substrates 31 are not formed in a coaxial structure, none of the contact probes is formed in a coaxial structure over the entire length thereof. A coaxial probe was formed such that the contact probes 1 are provided at a pitch of 0.5 mm; such that the outer diameter of the metal pipe 13 is set to 0.15 mm; and such that the inner diameter of the insertion hole 21 is set to 0.35 mm, to thus form the contact probes in a coaxial structure having a characteristic impedance of 50Ω. A return loss generated by the coaxial probe at frequencies was examined through simulation. As shown in Fig. 2, the return loss assumes a value of -20 dB or less at a frequency of about 10 GHz or less. Hence, no practical problem has arisen at actual use.

[0035]

According to the simulation, sufficient mechanical strength can be achieved at a border even when the insertion holes 21 assume an inner diameter of 0.35 mm and the coaxial probes are arranged adjacent to each other at a pitch of 0.4 mm.

[0036]

Fig. 3(a) is a cross-sectional descriptive view similar to Fig. 1(a), showing another example structure of the fixing means 3. Specifically, the structure of an upper portion of the contact probe 1 shown in Fig. 3(a) (i.e., the structure of a portion of the contact probe 1 where the plunger 11 is provided) is provided with a constriction section 23. The constriction section 23 is formed at one end of the insertion hole 21 of the metal block 2 by closing the insertion hole 21 exclusive of a through hole 22 through which the plunger 11 penetrates. Fixing means 33 is constituted of the metal block 2 having the constriction section 23 formed therein, and an insulating spacer 32 interposed between the constriction section 23 and the end of the metal pipe 13. The through hole 22 is formed in sufficient size so as not to contact the plunger 11. The insulating spacers 32 are formed from, e.g., polyetherimide. As shown in Fig. 3(b), the outer dimension of the insulating spacer 32 is brought in conformance with the shape of the insertion hole 21 and that of the constriction section 23. A recessed section 32a which enables insertion

of the end section of the metal pipe 13 is formed in the center of one side of the insulating spacer 32. Further, a through hole 32b which enables penetration of the plunger 11 is formed in the center of the recessed section 32a, and the thickness "t" of the insulating spacer 32 is about 0.5 mm.

[0037]

In Fig. 3(a), reference numeral 8 designates an insulation film which is formed from, e.g., a polyimide film, and has a thickness of about 0.1 mm. The insulation film is provided for preventing occurrence of, e.g., a short circuit, which would otherwise be caused when electrode terminals of the device to be inspected, such as an IC, come into contact with the metal block 2. If no such potential risk is present, the insulation film does not need to be provided, regardless of the fixing means 3.

[0038]

Fixing means provided on a lower portion of the contact probe 1 shown in Fig. 3(a) (i.e., a portion of the contact probe 1 where the plunger 12 is provided) assumes a structure identical with that achieved when the constriction section 23 of the upper fixing means is cut and separated in parallel. Specifically, the structure is achieved by setting the thickness of the metal block 2 to an extent to which the end section of the metal pipe 13 becomes exposed, and additionally forming a recessed section 24a and a through hole 24b, both being identical in shape with

the constriction section, in a metal cover 24. The metal cover 24 is fixed to the metal block 2 with unillustrated screws by way of the dielectric spacer 32 having the same shape as that of the upper fixing means. Specifically, fixing means 34 is constituted of the spacer 32 having the predetermined recessed section 32a and the through hole 32b formed therein, and the metal cover 24 having the predetermined recessed section 24a and the through hole 24b formed therein. In many cases, the surface (i.e., the lower surface in the drawing) of the metal cover 24 is connected to a wiring board (e.g., a PCB) formed by stacking, into a multilayer structure, films provided with wiring to be connected to inspection equipment, and earth conductors are provided on the surface of the wiring board exclusive of connected sections. Therefore, the metal cover 24 remains in its present form. However, as in the case of the upper surface, the lower surface may be provided with an insulating film, as required.

[0039]

Since there is a necessity for inserting the contact probe 1 into the insertion hole, at least one end of each of the insertion holes formed in the metal block 2 must be opened. Therefore, the previously-described constriction section 23 cannot be formed on both ends of each insertion hole. Therefore, as shown in Fig. 3(a), the other end of each of the insertion holes must be given a structure in which the metal block 2 is divided into

two sub-sections and one of the sub-sections is used as the metal cover 24 for covering the remaining part of the sub-section. Fixing means to be used at this time is substantially identical with that mentioned previously. However, if there is employed the structure of covering the remaining part of the sub-sections—into which the metal block 2 has been separated—through use of the metal cover 24, formation of the recessed sections 24a becomes very easy, thereby enabling inexpensive formation of the recessed sections. Therefore, the metal block 2 may be constituted in a three-layer structure, and there can be formed fixing means 34 which fix both upper and lower end sections of the insertion hole through use of a pair of sets each consisting of the metal cover 24 and the insulating spacer 32.

[0040]

When the structure shown in Fig. 3 is employed, the fixing means 33 is constituted of the insulating spacer 32 and metal, such as the metal block 2 or the metal cover 24, and the fixing means 33 can fix the contact probes with a smaller thickness and greater strength than those achieved by only the insulating substrate shown in Fig. 1(a). For instance, under the assumption that the load exerted on one contact probe is 10 gf and 1000 contact probes are provided, the fixing means experiences a spring pressure of 10 kgf. However, even in such a case, the fixing means can sufficiently retain the contact

probes. Moreover, metal exists in the neighborhood of the holes through which the plungers 11, 12 penetrate, and portions of the contact probe retaining a coaxial structure are long. Therefore, as can be seen from results of examination of the return loss shown in Fig. 4, the return loss being yielded by the coaxial probe at frequencies through simulation analogous to those shown in Fig. 2, a frequency range at which a return loss of -20 dB or less extends up to 28 GHz.

[0041]

Fig. 5 is cross-sectional descriptive view showing yet another example structure of the fixing means 3. As mentioned previously, this structure shown in Fig. 5(a) is achieved by imparting the metal block 2 with a three-layer structure, and the metal cover 24 is provided on either side of the metal block 2. The fixing means 34 is formed in each of the metal covers 24 along with the insulating spacer 32. Moreover, in this example, the inner diameter of the recessed section 24a formed in the metal cover 24 is set so as to become greater than the inner diameter of the insertion hole 21 formed in the metal block 2. The outer diameter of the insulating spacer 32 is formed so as to become substantially identical with the inner diameter of the insertion hole 21. Specifically, as in the case of the lower fixing means shown in Fig. 3, the fixing means itself corresponds to the fixing means 34 constituted of the metal cover 24 having the recessed section 24a, and the spacer

32. The diameter of the fixing means is slightly larger than the structure of the fixing means shown in Fig. 3. For instance, the diameter of the contact probe assumes a value of 0.15 mm and the inner diameter of the insertion hole 21 assumes a value of 0.35 mm, and the inner diameter of the recessed section 24a is formed so as to become larger than the inner diameter of the insertion hole 21 by about 0.15 mm.

[0042]

As mentioned above, as a result of the outer diameter of the insulating spacer 32 being formed slightly larger, there can be maintained the diameter of the coaxial outer conductor which becomes optimum as a result of insertion of a dielectric substance into the insulating spacer, thereby enabling an improvement in high-frequency characteristic. In other respects, the structure of the fixing means is identical with that shown in Fig. 3, like elements are assigned like reference numerals, and their explanations are omitted.

[0043]

The structure of an upper-surface-side of the fixing means shown in Fig. 5(b) is identical with that of the upper fixing means 33 shown in Fig. 3(a). The fixing means 33 is constituted of the metal block 2 having the insulating spacer 32, and the constriction section 23.

[0044]

In relation to a lower-surface-side of the fixing means,

a spacer fitting recessed section 25—which is larger in inner diameter than the insertion hole 21—is formed in the surface of the metal block 2 located at the end section of the insertion hole 21. A dielectric spacer 35 is inserted into one end section of the contact probe 1 and the spacer fitting recessed section 25 of the metal block 2, wherein the dielectric spacer 35 has a recessed section 35a whose diameter conforms to the outer diameter of the extremity of the metal pipe 13, and a through hole 35b through which the plunger 12 penetrates substantially concentrically with the recessed section 35a. Since the dielectric spacer 35 is not fixed in this state, the contact probe 1 is not fixed either. However, the metal block 2 is usually fixed with screws while a lower portion of the metal block 2 remains in contact with the wiring board 5 formed from multiple layers. As a result of the metal block 2 being fixed to the wiring board 5, the dielectric spacer 35 is fixed firmly, and the contact probe 1 is also fixed concentrically with the insertion hole 21. Specifically, in this embodiment, fixing means 36 is constituted of the metal block 2 having the spacer fitting recessed section 25; the dielectric spacer 35 having the recessed section 35a and the through hole 35b; and the wiring board 5.

[0045]

By such a configuration, the contact probe 1 can be fixed concentrically with the insertion hole 21 by only the metal

block 2, the insulating spacer 32, and the dielectric spacer 35. Fixing of the contact probe 1 can be achieved with use of a smaller number of components, and also a non-coaxial portion hardly arises. In this case, impedance mismatch can be corrected by adjusting the depth and inner diameter of the spacer fitting recessed section. Consequently, there is yielded a merit of the ability to inexpensively manufacture a high-performance coaxial probe.

[0046]

In the structure shown in Fig. 5(c), an insulating spacer 37 to be used for fixing a contact probe is constituted of a first spacer 37a provided around the metal pipe 13 of the contact probe 1, and a second spacer 37b provided around the plungers 11, 12. Further, fixing means 38 is constituted of the metal block 2 in which steps 26, 27 corresponding to the respective spacers are formed, and fixing means 39 is constituted of the metal cover 24 in which similar steps 26, 27 are formed. By such a structure, the dielectric spacer 37 can be formed in a simple ring shape. Different materials can be used for the two rings. Specifically, the only requirement for the first spacer 37a is to ensure concentricity between the contact probe 1 and the insertion hole 21, and the first spacer 37a does not require much mechanical strength. Therefore, the first spacer 37a can be formed from polytetrafluoroethylene having a small dielectric constant and a thickness of about 0.3 mm. As in

the case of the structure shown in Fig. 5(a), the influence of impedance mismatch can be inhibited without involvement of an increase in the diameter of the insulating spacer.

[0047]

The second spacer 37b is for fixing the longitudinal position of the contact probe 1. The contact probe 1 is fixed by the surface of the second spacer 37b contacting the end face of the metal pipe 13, and another surface of the same contacting the metal block 2 or the metal cover 24. Since the longitudinal force of the contact probe 1 is great, the contact probe 1 can be sufficiently retained through use of polyetherimide (PEI) having high mechanical strength and a thickness of about 0.3 mm. Polyetherimide (PEI) has a high dielectric constant, and hence the inner diameter of an outer conductor must be larger than the outer diameter of the center conductor of the coaxial structure. However, the center conductors are the narrow plungers 11, 12 and have high dielectric constants. Hence, it is preferable for the dielectric constant and the outer diameter of the second spacer 37b to be larger, because a contact area between the second spacer 37b and the metal block 2 or a contact area between the second spacer 37b and the metal cover 24 can be made large, so that the second spacer 37b can retain the contact probe 1 tightly.

[0048]

In the embodiment shown in Fig. 5(c), the first spacer

37a has the same diameter as that of the insertion hole 21. In reality, the first spacer 37a is given a diameter slightly larger than that of the insertion hole 21 and is press-fitted into the insertion hole 21. Since no longitudinal force is exerted on the first spacer 37a, the contact probe can be retained sufficiently. As a matter of course, impedance matching can be achieved between the coaxial structures [i.e., the relationship expressed by Equation (1) can be achieved], by adopting the configuration of the fixing means 39 and making the outer diameter of the first spacer 37a slightly larger (it can be smaller than the case of Fig. 5(a)) than the inner diameter of the insertion hole 21, as in the case of the structure shown in Fig. 5(a), thereby enhancing the high-frequency characteristic and forming a space to be used for retaining the first spacer 37a.

[0049]

As mentioned above, according to the coaxial probe of the present invention, the contact probe is fixed in the insertion hole formed in the metal block in a hollow state. The coaxial structure formed from the contact probe and an inner wall of the metal block is constituted of the center conductor and the outer conductor by way of the dielectric substance having a relative dielectric constant ε_r of nearly one. Impedance of 50 Ω can be achieved, by making the inner diameter of the outer conductor about 2.3 times as large as the outer diameter of

the center conductor. Consequently, a coaxial structure can be formed through use of a contact probe having an outer diameter of 0.15 mm or thereabouts even when the pitch between electrode terminals is about 0.4 mm. Therefore, a coaxial probe capable of performing inspection can be obtained inexpensively without involving occurrence of a loss, which would otherwise be caused by the inductance of a connected section.

[0050]

An inspection unit for inspecting a device to be inspected through use of the coaxial probe will be described by reference to Figs. 6 and 7. Figs. 6 and 7 shown an example IC socket to be used for inspecting an IC or a module. Fig. 6(a) is a descriptive plan view of the socket when no IC is mounted thereon, and Fig. 6(b) is a cross-sectional descriptive view of the socket taken along line B-B. Fig. 7(a) is a descriptive plan view of an IC socket mounted on a wiring board and an IC socket set on the IC socket, and Fig. 7(b) is a cross-sectional descriptive view of the same taken along line B-B.

[0051]

Specifically, the inspection unit of the present invention is provided with RF signal contact probes 41 provided in the metal block 2 such that the extremities of the plungers 11, 12 which are movable toward one surface of the metal block 2 (both surfaces of the metal block 2 in the embodiment shown in Fig. 6). Each of the RF contact probes 41 is formed from

the coaxial probe shown in Fig. 1. The RF signal contact probe 41 is fixed within the insertion hole 21 formed in the metal block 2 while being retained in a hollow space, by the fixing means formed from the insulating substrate 31. Thus, a coaxial structure of the predetermined characteristic impedance is achieved. A contact probe adjacent to the RF signal contact probe 41 is an earth probe 42, wherein the metal pipe 13 shown in Fig. 1(b) is fixed directly within the insertion hole of the metal block 2. A guide plate 43 for positioning and guiding an IC is placed on the upper surface of the insulating substrate 31 and fixed to the insulating substrate 31 along with the metal block 2 by the screws 44. The lower insulating substrate 31 in the drawing is also fixed to the metal block 2 by screws 45. Reference numeral 46 designates positioning pins used for fixing the IC socket to the wiring board 5.

[0052]

As shown in Fig. 7, the IC socket is fixed on the wiring board 5 through use of the previously-described positioning pins 46, whereupon the plungers 12 located on the lower parts of the contact probes are withdrawn. As a result, the wiring board 5 and the insulating substrate 31 are brought into contact with each other and fixed together by unillustrated screws. Further, when an IC 47 is inserted and pressed against a recessed section 43a of an upper guide plate 43, the corresponding upper plunger 11 is also depressed. By upward driving force of the

spring 14 provided in the contact probe 1 (see Fig. 1), one of electrode terminals 47a of the IC 47 is tightly, electrically connected with the plunger 11 of the contact probe 1. As a result, the IC is connected to the inspection equipment connected to the wiring board 5, thereby enabling inspection of an electrical characteristic of the IC. At this time, the RF signal contact probe 41 connected to an RF electrode terminal of the IC 47 is embodied as the coaxial probe 41. Hence, impedance matching is achieved between the IC 47 and the wiring board 5, and hence the IC 47 can be inspected accurately without any loss.

[0053]

When the plurality of electrode terminals of the IC 47 are connected with the wiring board 5 by way of the IC socket, the wiring board 5 is constituted into a multilayer structure. Further, wiring is formed such that respective wiring patterns assume specific impedance of 50 Ω or the like.

[0054]

Although the embodiments shown in Figs. 6 and 7 are directed to the embodiment of the IC socket, the present invention can be applied in the same manner to another inspection unit, such as an inspection jig used for inspecting the module shown in Fig. 8. Even when an IC is for high-frequency, high-speed purposes and the electrode terminals are formed at a very small pitch, the IC can be inspected very stably through use of the

coaxial probe of the present invention without involving attenuation of a signal.

[0055]

In the case of the previously-described IC socket, the plungers which move at both ends of each of the probes must be employed. When the lower side of contact probe is fixed to the wiring board at all times by the inspection jig, the only requirement for the plungers is to be formed not in the form of a movable plunger but so as to be fixedly connected to the wiring board by soldering. Only the plunger located on the part of the contact probe, the part being brought into contact with a device to be inspected and replaced, must be movable.

[0056]

[Advantage of the Invention]

According to the invention, there is adopted a coaxial contact probe utilizing a hollow space. Hence, the diameter of an outer conductor can be reduced while a thick probe is used for a contact probe serving as a center conductor. Even when the contact probes are connected to electrode terminals arranged at a pitch of 0.4 mm, the probe can be constituted of coaxial probes, each using a thick contact probe having a diameter of 0.15 mm or thereabouts. Therefore, the probes can be manufactured very inexpensively, and signals can be transmitted without attenuation. Consequently, even when a

device corresponding to a high-frequency, high-speed device—for which considerable progress has been recently made and for which a pitch between electrode terminals is made smaller—is inspected before mounted on a circuit board, the IC can be inspected while being connected to RF signal terminals by a coaxial structure. The IC can be inspected very accurately and with high reliability without involvement of attenuation of a signal.

[Brief Description of the Drawings]

Fig. 1 is cross-sectional descriptive view showing the configuration of an embodiment of a coaxial probe according to the present invention.

Fig. 2 is a figure showing a return loss characteristic of the coaxial probe shown in Fig. 1 achieved at various frequencies.

Fig. 3 is a cross-sectional descriptive view showing another embodiment of the coaxial probe of the present invention.

Fig. 4 is a figure showing a return loss characteristic of the coaxial probe shown in Fig. 3 achieved at various frequencies.

Fig. 5 is cross-sectional descriptive view showing yet another embodiment of the coaxial probe of the present invention.

Fig. 6 is structural descriptive view of an IC socket which is an example of an inspection unit according to the present invention.

Fig. 7 is structural descriptive view of an IC socket which is an example of an inspection unit according to the present invention.

Fig. 8 is a structural descriptive view showing an example of a conventional RF device inspection jig.

Fig. 9 is structural descriptive view showing an example of a conventional IC socket.

[Descriptions of the Reference Numerals]

1 CONTACT PROBE

2 METAL BLOCK

3 FIXING MEANS

11, 12 PLUNGERS

13 METAL PIPE

21 INSERTION HOLE

23 CONSTRICTION SECTION

24 METAL COVER

31 INSULATING SUBSTRATE (FIXING MEANS)

32 INSULATING SPACER

41 RF SIGNAL PROBE

[Designation of the Document] Abstract of the Disclosure

[Abstract]

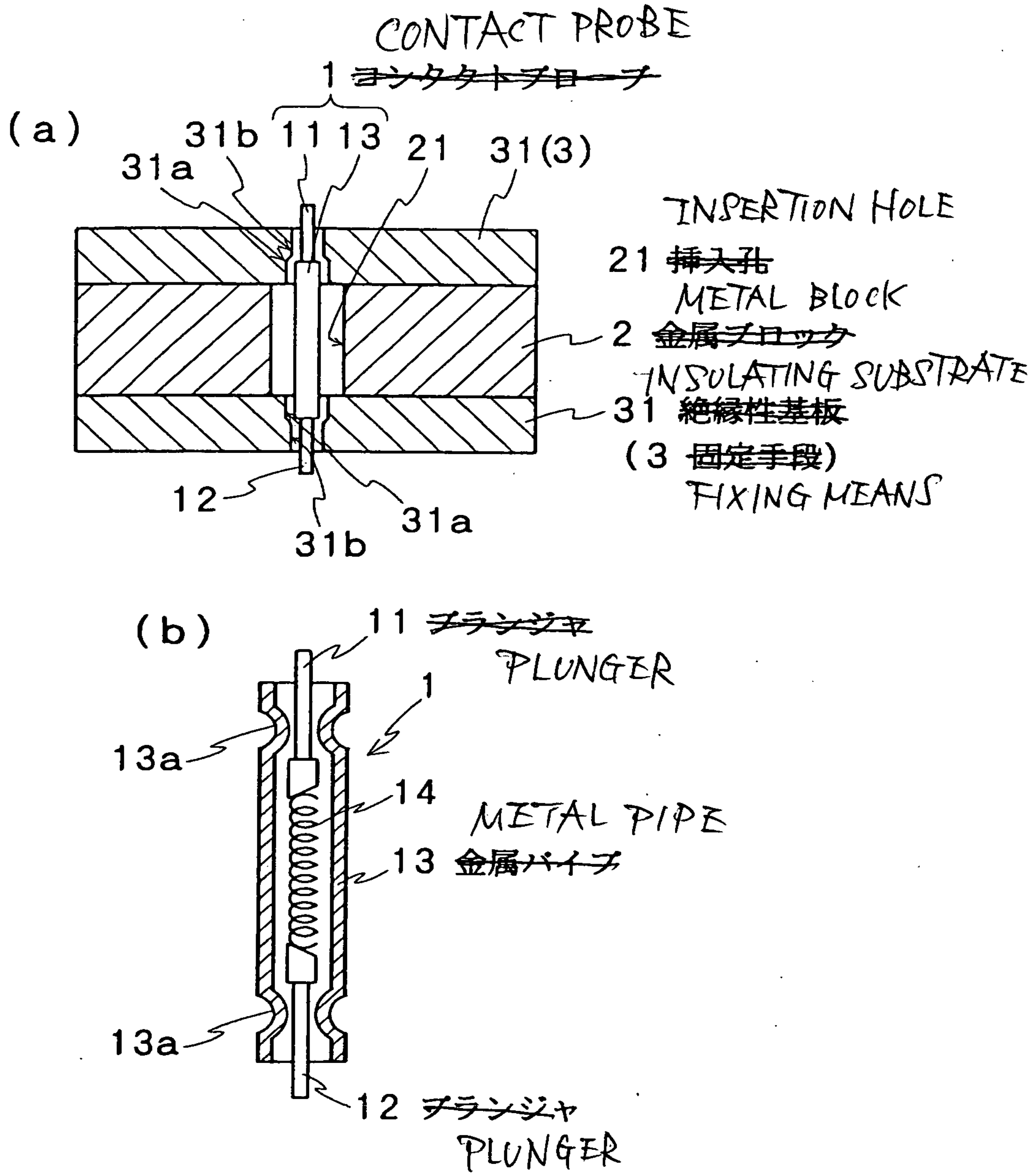
[Problem] To providing a inspection coaxial probe for an RF device, which can perform highly-reliably inspection without being affected by noise, through use of inexpensive contact probes having coaxial structures even when a recent RF device having electrode terminals arranged at a very small pitch is to be inspected.

[Means for Resolution] A contact probe 1—which enables adjustment of lengths to which plungers 11, 12 project from a metal pipe 13—is inserted into an insertion hole 21 of a metal block 2. There is provided fixing means 3 for fixing the contact probe 1 to the metal block 2 by way of an insulating substrate 31 for retaining an end section of the metal pipe substantially concentric with the insertion hole 21. An outer diameter of the metal pipe 13 and an inner diameter of the insertion hole 21 are set such that a coaxial structure of predetermined impedance is formed while the contact probe 1 is taken as a center conductor and the metal block 2 is taken as an outer conductor.

[Selected Drawing] Fig. 1

Designation of Document
~~【書類名】~~ ~~図面~~ Drawing

~~【図1】~~
Fig. 1



~~【図2】~~ FIG.2

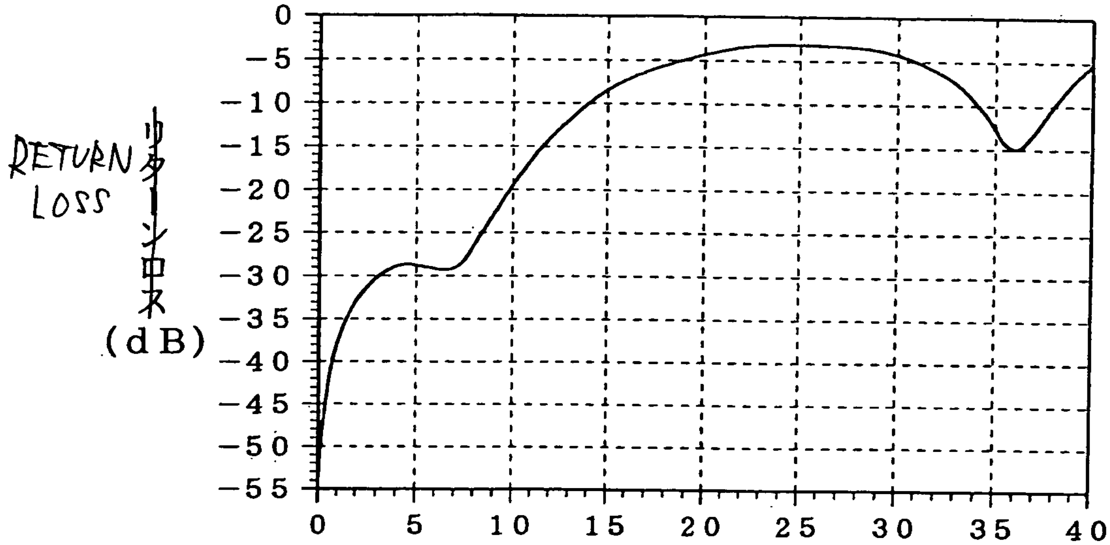


FIG.3

~~【図3】~~

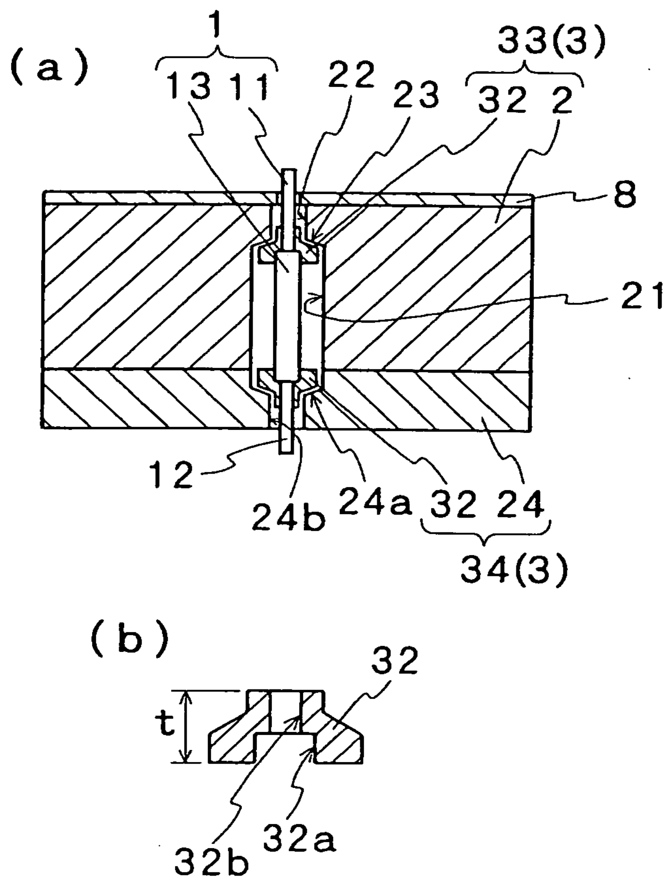
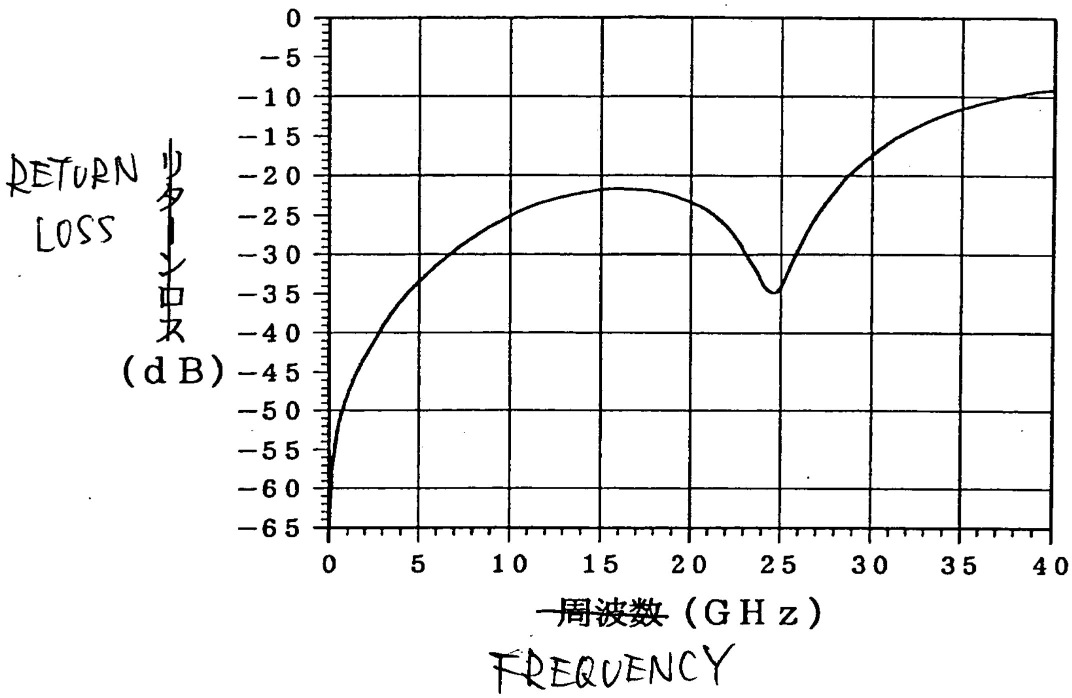


FIG.4

~~【図4】~~


RETURN LOSS
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(dB)
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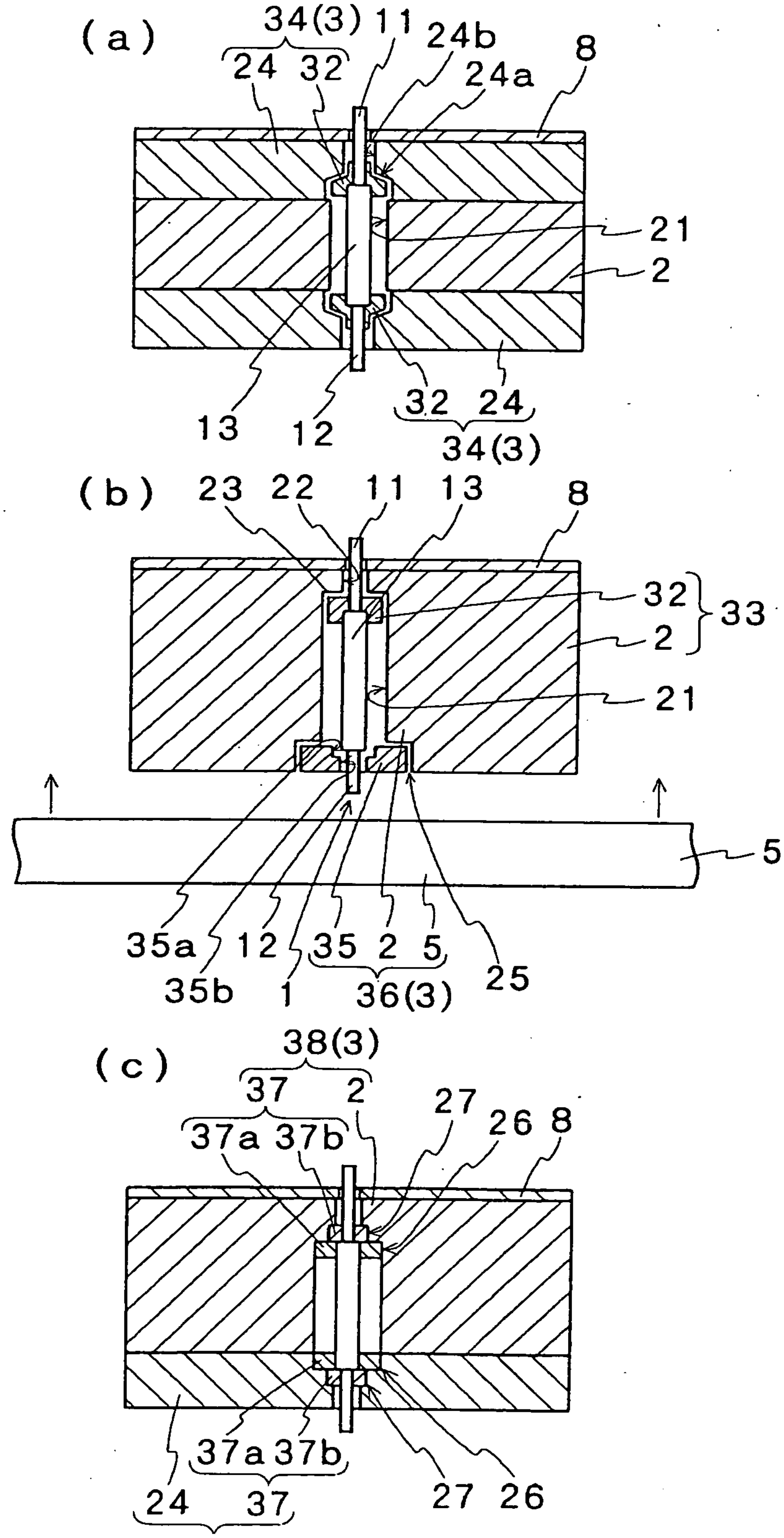
−5
−10
−15
−20
−25
−30
−35
−40
−45
−50
−55
−60
−65
0
5
10
15
20
25
30
35
40
~~周波数~~ (GHz)
FREQUENCY

~~【図5】~~

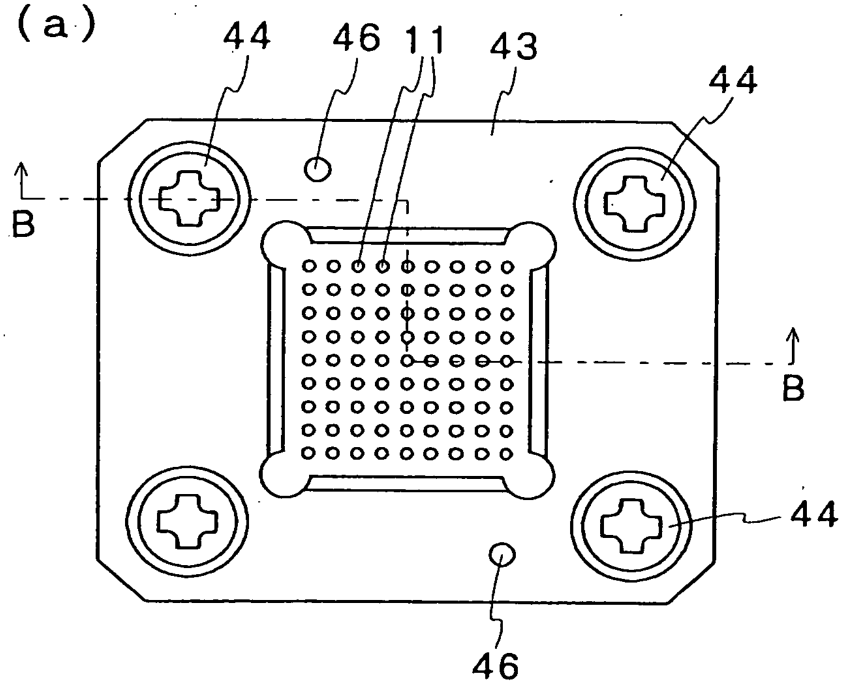
FIG.5



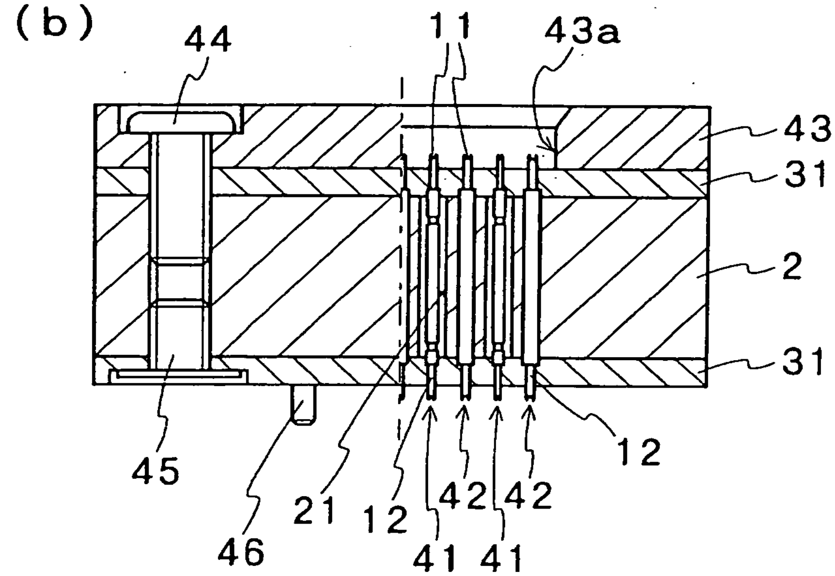
(a)
34(3)
24
32
11
24b
24a
8
21
2
13
12
32
24
34(3)
(b)
23
22
11
13
8
32
2
33
21
5
35a
35b
12
1
35
2
5
36(3)
25
(c)
38(3)
37
2
37a
37b
27
26
8
37a
37b
37
24
37
27
26

~~【図6】~~
FIG. 6

(a)

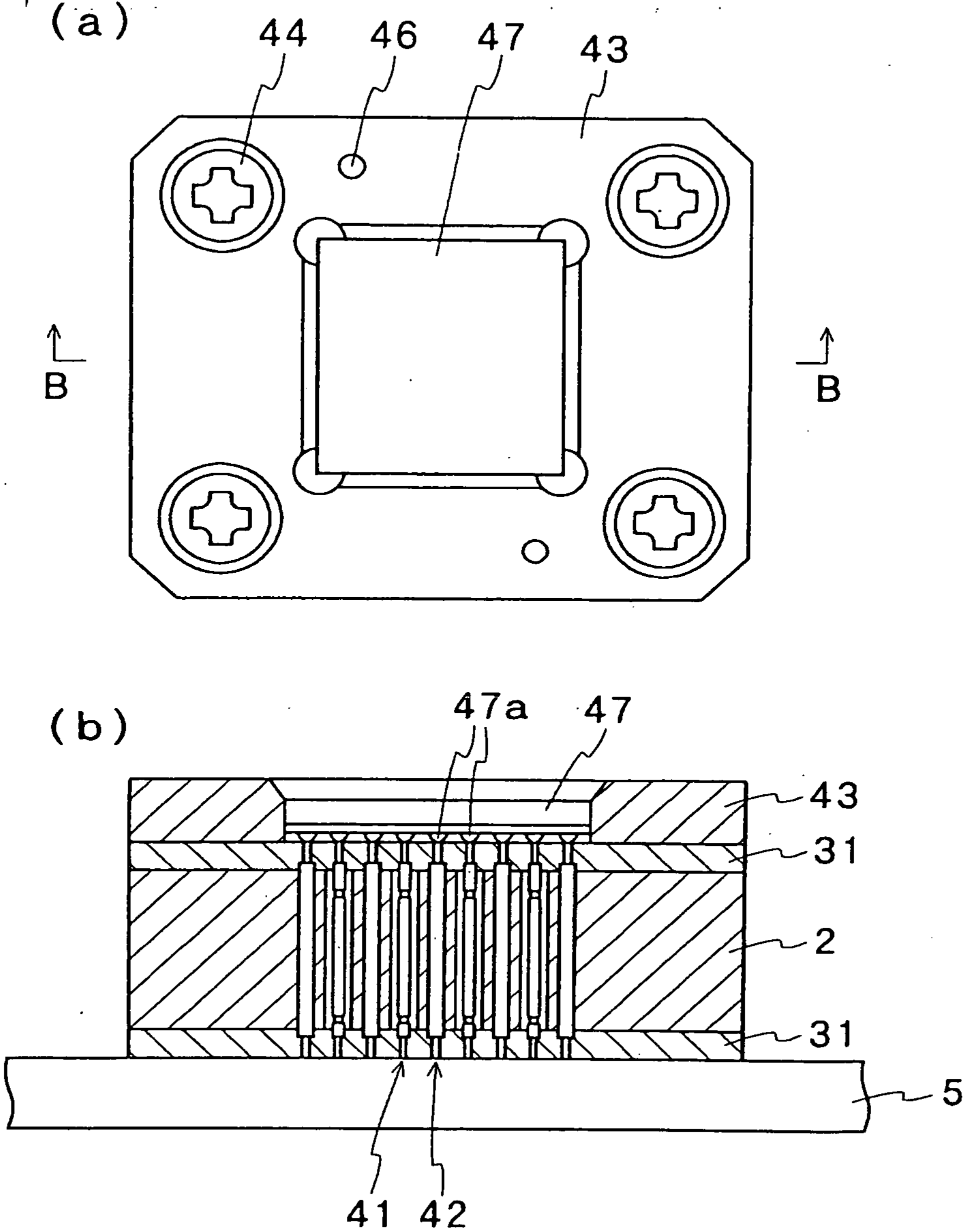


(b)

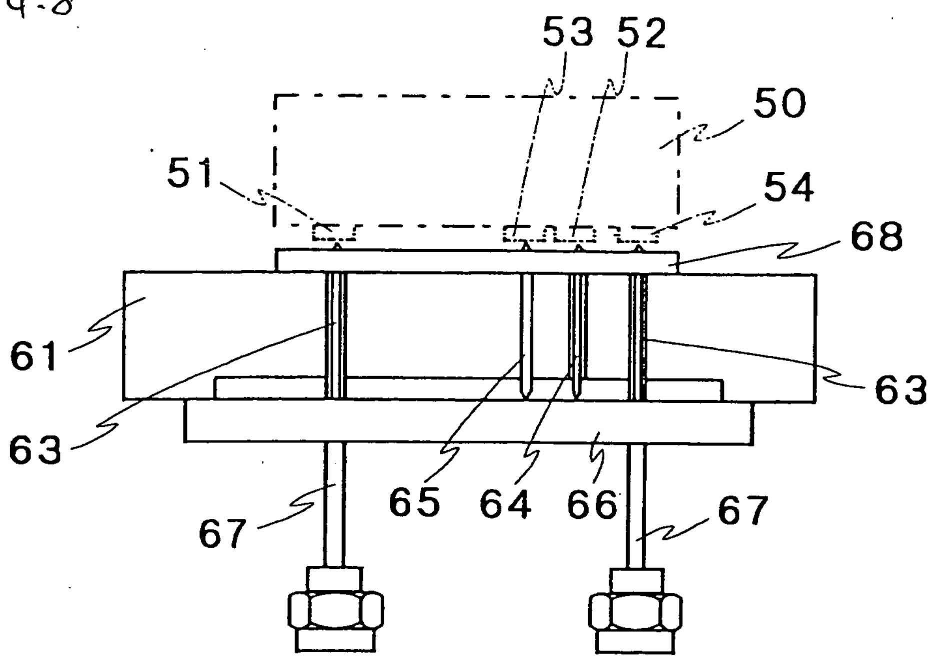


~~【図7】~~

FIG. 7



~~【図8】~~
FIG.8



~~【図9】~~
FIG. 9